MAGNETIC SIGNATURES OF LARGE METEORITES. P. J. Wasilewski[1], T. L. Dickinson[2], J. E. Connerney[3], and M. Funaki[4], [1]Mail Code 691, NASA Goddard Space Flight Center, Greenbelt, MD 20701, USA, u1pjw@lepvax.gsfc.nasa.gov, [2]Physics Department, Catholic University of America, Washington D.C., 20064, USA, u1tld@lepvax.gsfc.nasa.gov or tdickins@nsf.gov, [3]Mail Code 695.0, NASA Goddard Space Flight Center, Greenbelt MD 20771, USA, john.e.connerney.1@gsfc.nasa.gov, [4]National Institute of Polar Research, 9-10 Kaga, 1 Chome, Itabashi-Ku, Tokyo. 173, Japan, funaki@decst.nipr.ac.jp.

The NEAR (Near Earth Asteroid Rendezvous) spacecraft is scheduled to encounter 433 EROS, a representative S-type asteroid, in June 1997 and will measure its composition and structure to address questions on the origin and evolution of near-Earth objects. Galileo's flybys of the asteroids Gaspra and Ida suggested a measurable magnetic field [1]. The NEAR magnetometer will map the magnitude and geometry of the Eros' magnetic field and its spatial relationship to the geometry of the asteroid. These data will help to identify the link between asteroids and meteorites and will help to determine whether asteroids are solid objects or are fragmented rubble piles.

Meteorites preserve a wide variety of paleomagnetic records which were imprinted during exposure to magnetic fields at various stages in their history [2,3]. A major unresolved issue in meteorite magnetism research is deciphering the complex nature of the magnetic records. Our present knowledge of magnetic properties of meteorites comes from laboratory studies of samples that, in most cases, are less than 100's of grams.

The most recent compilation of the natural remanent magnetism (NRM) for a variety meteorites indicates that the NRM intensity varies by several orders of magnitude for many classes of meteorites [4]. Initial NRM and alternating field demagnetization behavior for samples of Olivenza from four different sources vary widely [5]. Some of this difference may be due to magnetic contamination, which is best identified by the REM value (ratio of natural remanence (NRM) to saturation remanence (SIRM)). For example, REM values for Olivenza [5] range from 0.00006 to 0.6. The REM values for chondrite meteorites, including the carbonaceous chondrites, range over four orders of magnitude (e.g. [6]; unpublished Goddard data).

Meteorite magnetization is the consequence of the composition and microstructure of kamacite and taenite. Wasilewski [7] reported NRM values between 7.6 to 25.2 x 10^{-4} Am^2kg^{-1} and SIRM between 283 to 1307 x 10^{-4} Am^2kg^{-1}, yielding REM values between 0.02 and 0.03 for a range of kamacite compositions. The NRM and SIRM vary linearly with Ni content for these kamacite compositions. The corresponding NRM and SIRM for $Fe_{51}Ni$ (i.e. tetrataenite composition) is 1.5 and 88.4 x 10^{-4} Am^2kg^{-1}, respectively, with REM value of 0.02 [7]. Dickinson and Wasilewski [8] show that shock can reduce REM by 1-2 orders of magnitude and their evaluation of all known mechanisms of magnetization for iron oxides, metals and alloys shows REM to be less than 0.1. The compilation by [4] does not include an evaluation of REM or other discriminators which would address contamination and the influence of shock or other factors.

Magnetic records of meteorite subsamples (oriented pieces of small meteorites) have been studied by numerous investigators. Results show that carbonaceous chondrites have fairly coherent magnetic vector records in the subsample arrays [9]. Subsamples of ordinary chondrites show widely scattered to near random vector records regardless of the level of metamorphism [10]. There are no subsample records for iron meteorites. In Olivenza, [5] showed that the inhomogeneity was present down to the 50 mg scale.

We are measuring the magnetic signatures of four large (up to 1150Kg) meteorites obtained from the Smithsonian Natural History Museum - Allende (carbonaceous), ALH 76009 (ordinary chondrite), Canyon Diablo and Goose Lake (irons). This data will help us to decipher the complex nature of meteorite magnetic records, will provide a model for interpreting NEAR spacecraft magnetometer data and will enable us to examine the link between meteorites and asteroids. In addition, Canyon Diablo and Goose Lake are microstructurally different enough to investigate the influence of shock, including the shock transitions and post shock heating.

The samples will be assigned a coordinate system and placed at the center of the NASA-GSFC 40 foot coil system, fully within the region where intensity and gradient of the magnetic field can be accurately controlled. Two three-axis fluxgate magnetometers will record the field intensity in the x, y, and z directions on three mutually perpendicular axes as the meteorite is rotated through 360°. The data will be analyzed using spherical harmonic analysis conventionally used in studies of the earth's magnetic field. Schmidt normalized spherical harmonic coefficients will be derived for the spherical harmonic fit to the data. The first set of measurements will be done in zero field to map the remanent magnetization. The second set of measurements will be done after AC demagnetization in a 5 mT field to assess the magnetic noise acquired from the geomagnetic field. The third set of measurements will be done with an applied field of about 20 mT to evaluate the directional effect of an induced component, comparable to interplanetary conditions, on the remanent magnetization. We will also measure the magnetic properties of small samples of each meteorite in the laboratory to determine the nature of the magnetization and the effect of shock. This data will provide a very detailed representation of the magnetic signature of the meteorites.

We will use this new data and literature data for small meteorite samples to produce a framework for the magnetic properties of the asteroids, anticipating the NEAR encounter with EROS.

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